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EVALUATION OF SYNTHETIC HYDROCARBON INSTRUMENT BEARING OILS

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The work reported herein resulted from the testing of three viscosity grade synthetic hydrocarbon oils to determine their suitability as replacements for Specification MIL-L-83176 super-refined mineral oils. The results of the tests were used to compare properties of these oils in addition to those of an ester type instrument bearing oil qualified to Specification MIL-L-18486. The results show the synthetic hydrocarbon oils, of comparable viscosity, to possess superior chemical and physical properties to

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those of the MIL-L-83176 type mineral oils and similar properties to the MIL-L-18486 ester oils. Comparisons of R-4 Bearing Performance Tests show operating lives of 4-10 times greater for the synthetic hydrocarbon oils than for the mineral and ester oils.

Based on these results proposed specification requirements were developed to cover the use of synthetic hydrocarbon oils for instrument bearing application.

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INTRODUCTION

Instrument bearing lubrication is a very specialized field and can be quite demanding in terms of requirements for the lubricant, e.g., low uniform torque characteristics, thermal stability and good lubricity. There is a very low market volume for this type of lubricant which results in limited availability or use of materials designed for these applications. The work reported herein was conducted to evaluate a series of synthetic hydrocarbon fluids as multipurpose instrument bearing oils.

BACKGROUND

The bearing lubricant for the G-200 gyro used in the inertial navigation system on the F-4 aircraft is a single source product. This material, which is covered by Military Specification MIL-L-83176 is a special super refined mineral oil which is no longer available on a regular production basis. A replacement for this fluid is urgently needed. One type of fluid that is being considered is synthetic hydrocarbon fluid. The first major use of this class of fluids was in the manufacture of wide temperature range grease covered by Specification MIL-G-81322. It is also used as the major component in MIL-H-83282 hydraulic fluid. Synthetic hydrocarbon fluids are now being used in a number of non-military applications as industrial gear and bearing lubricants, automotive engine oils and gas turbine lubricants. Some of the outstanding properties of these oils include: (1) high viscosity index, (2) good thermal stability, (3) receptiveness of common additives and inhibitors, (4) low temperature fluidity and (5) compatibility with other lubricants and materials. In addition, synthetic hydrocarbon fluids are readily available and expected to remain so.

DISCUSSION

TEST FLUIDS

Test fluids consisted of three commercially available synthetic hydrocarbon (SH) oils of different viscosity grades (Samples A, C and D). A super-refined mineral oil (Sample B) meeting Specification MIL-L-83176 and an ester based fluid (Sample E) meeting Specification MIL-L-81846 were also evaluated for purposes of comparison. The SH oil Sample A has a viscosity similar to that of Sample B and SH Oil Sample C viscosity is similar to that of the ester Sample E while Sample D viscosity is intermediate among these samples. Each of the SH oils contain the antiwear agent Tricresylphosphate (TCP) and an oxidation inhibitor of the hindered phenol type.

TEST PROGRAM

Viscosity, viscosity index, pour point and flash point tests were run in accordance with applicable ASTM methods. Viscosities were determined at 38°C (100°F) and 99°C (210°F) for all samples, at -40°C (-40°F) for

Samples C, D and E and at -54°C (-65°F) for Samples C and E. Evaporation tests were conducted in accordance with ASTM Method D-972 except that the test temperature was 177°C (350°F) and a gravity convection oven was used instead of an oil bath.

Oxidation-corrosion tests were conducted using Method 5308 of FTMS No. 791, with the following exceptions:

1. Test duration and temperature - changed from 168 hours at 121°C (250°F) to 72 hours at 177°C (350°F).

2. Test specimens - Steel (QQ-S-698), Magnesium (QQ-M-44, A231B) and Cadmium (QQ-A-671) changed to Stainless Steel (QQ-S-766) Steel (QQ-S-624) and Silver (MIL-S-13282 - Grade A).

Thin film stability tests were conducted in accordance with paragraph 4.4.1 of Specification MIL-L-81846. Four-ball wear tests were conducted in accordance with ASTM Method D-2266 for lubricating grease. In addition to the standard conditions (load - 40 Kg, speed - 1200 RPM, temperature - 75°C (167°F), test specimen - 52100 steel) tests were also conducted under the following conditions:

1. Load - 20 and 10 Kg, Speed - 1200 RPM, Temperature - 75°C (167°F), and Specimen - 52100 steel

2. Load - 40 and 20 Kg, Speed - 600 RPM, Temperature - 75°C (167°F), Specimen - AISI 440°C passivated stainless steel

Bearing lubricant life tests were performed on all but the Sample D. These tests were conducted in accordance with ASTM Method D3337 for grease, except that the bearings used had phenolic retainers. They were supplied by MPB Corporation with the designation SR4MCHH7. Also, the retainers were vacuum impregnated with the test lubricant by the bearing supplier. The test temperature was 149°C (300°F) for Samples A and B and 121°C (250°F) for Samples C and E.

R E S U L T S

The results of tests conducted in this program are shown in Tables I through VI. The requirements of Specifications MIL-L-81846 and MIL-L-83176 were used where applicable, for purposes of comparison.

A comparison of the physical and chemical properties of the oils are shown in Tables I and II.

The viscosity at 99°C (210°F) of Sample A is almost the same as that of Sample B. However, Sample A has a higher viscosity index than Sample B. This results in better low temperature properties for the Sample A, i.e., lower viscosity at low temperatures and lower pour point.

The Sample C physical properties compare closely with those of Sample E-ester while the Sample D properties fall between those of Sample A and Sample D.

Substantial differences exist, among the oils tested, in their resistance to oxidation. These differences are most evident from the percent change in viscosity of the oils after testing. Although the oils all show significant increase in acid numbers, the effects on the metallic specimens is very small. While no oxidation-corrosion tests were conducted on Sample E under this program, the requirement of Specification MIL-L-81846 indicate that this oil has excellant oxidative resistance. Typical instrument bearing applications require extremely minute quantities of lubricant, so that high ratios of bearing surface area to lubricant volume exist for the entire life or maintenance cycle of the bearing. Thin film properties can be quite different from bulk properties of a lubricant.

The volatility results, both in the thin film and the bulk tests, follow the order of fluid viscosity. However, the appearance and flow properties of the Sample E-ester oil, following the thin-film exposure, shows superior qualities over the other oils tested.

Four-ball wear tests are most frequently conducted using standard 52100 steel ball specimens. However, the majority of instrument bearings in use today are fabricated from 440C stainless steel. Stainless steel is much more difficult to lubricate than 52100 steel under boundary conditions. Both 52100 and stainless steel test balls were used in this program for four-ball wear tests. The results of four ball wear tests are shown in Tables III and IV.

The results of the R-4 bearing-lubricant life tests are shown in Tables V and VI. The failure criteria for these tests was a 500% increase in torque over the steady state of the established one hour after reaching test temperature on the first cycle.

Results that show lives of 20 hours or even multiples of 20 hours indicate that failure occurred on startup for the next cycle. Results that show lives other than even multiples of 20 hours indicate that failure occurred during the running cycle.

A cursory post-mortem visual inspection of the bearings provided some indication of the reasons for failure. Each of the bearings run with the Sample B lubricant showed a large amount of oil remaining in the bearing after failure. The oil appeared to be reasonably free of wear debris and lubricant degradation products. However, the oil showed a very noticeable increase in viscosity indicating that lubricant oxidation was the probable cause of failure.

For synthetic hydrocarbon oils (Samples A and C) and the ester oil (Sample E), lubricated bearings showed a different appearance after failure. In each case, the bearings contained only very minor amounts

of lubricant along with considerable wear debris. The reason for failure appeared to be lack of lubricant. The loss of lubricant could have been from one or a combination of factors such as evaporation, oxidation and oil migration. Proposed specification requirements for the SH oils are shown in Appendix A.

CONCLUSION

Based on the results of the laboratory tests conducted, the synthetic hydrocarbon oils are considered as excellent candidates for use as multi-functional instrument bearing lubricants. Their high viscosity indices, low pour points, good oxidation and wear resistance and excellent bearing operating lives provide high potential for reducing the number of lubricants required for use in instrument bearings.

RECOMMENDATIONS

It is recommended that a specification be issued incorporating the requirements shown in Appendix A.

TABLE I. PHYSICAL AND CHEMICAL PROPERTY TEST RESULTS FOR SAMPLE A (SH) AND SAMPLE B (MIL-L-83176) FLUIDS

Test	Method	Results		MIL-L-83176 Requirement
		Sample A	Sample B	
Viscosity, cSt @ 99°C (210°F)	ASTM D445	14.41 cSt	14.96 cSt	14.76 - 15.78 cSt
@ 38°C (100°F)	ASTM D445	120.9 cSt	165.1 cSt	Report
Viscosity Index	ASTM D2270	131	98	100 Min.
Pour Point, °C (°F)	ASTM D97	-43°C (-45°F)	-21°C (-5°F)	25°F Max.
Flash Point, °C (°F)	ASTM D92	266°C (510°F)	288°C (550°F)	500°F Min.
Thin Film Stability 6½ hrs. @ 177°C (350°F)	MIL-L-81846 Para. 3.7			
(a) Evaporation, %		47.0%	31.0%	--
(b) Tackiness		Very slight	Very slight	--
(c) Lacquer/sludge		Very little lacquer	Very little lacquer	--
(d) Flow		Slightly restricted	Moderately restricted	--
Evaporation, %, 22 Hrs. @ 177°C (350°F)	ASTM D972	5.34%	2.32%	--
Acid No. mg of KOH/2	ASTM D974	0.03 mg of KOH/g	0.03 mg of KOH/g	--
Corrosion - Oxidation* 72 Hrs. @ 177°C (350°F)	FTM 5308			* 48 Hrs. @ 140°C (300°F)
(a) % Change in Vis. @ 38°C (100°F)		+0.6%	+61.0%	-5 to +20%
(b) Change in Acid No.		+1.76	+4.70	2.0 Max.
(c) Appearance After Test		Small amount of light colored insolubles	Small amount of dark colored insolubles	

TABLE I. PHYSICAL AND CHEMICAL PROPERTY TEST RESULTS FOR SAMPLE A (SH) AND SAMPLE B (MIL-L-83176) FLUIDS (Continued)

Test	Method	Results		MIL-L-83176 Requirement
		Sample A	Sample B	
(d) Change in Wt. (mg/cm^2)	FTM 5308			
(1) 410 Steel		0.1 mg/cm^2	0.1 mg/cm^2	--
(2) 52100 Steel		0.00 mg/cm^2	0.01 mg/cm^2	--
(3) Silver		0.01 mg/cm^2	0.00 mg/cm^2	--
(4) Copper		0.04 mg/cm^2	0.16 mg/cm^2	0.6 mg/cm^2 max.
(5) Aluminum		0.02 mg/cm^2	0.00 mg/cm^2	--

* 5 liters of air/hr. is passed through sample

TABLE II. PHYSICAL AND CHEMICAL PROPERTY TEST RESULTS FOR SAMPLES C, D AND E FLUIDS

Test	Method	Results			MIL-L-81846 Requirement
		Sample C	Sample D	Sample E	
Viscosity, cSt @ 99°C (210°F)	ASTM D445	3.68 cSt	9.94 cSt	3.58 cSt	3.45 cSt Min.
@ 38°C (100°F)	ASTM D445	17.53 cSt	66.32 cSt	14.2 cSt	14.0 cSt Min.
@-40°C (-40°F)	ASTM D445	2549 cSt	27504 cSt	1886 cSt	--
@-54°C (-65°F)	ASTM D445	9987 cSt	--	12124 cSt	13000 cSt Max.
Viscosity Index	ASTM D2270	119	146	158	--
Pour Point, °C (°F)	ASTM D97	-65°C (-85°F)	-54°C (-65°F)	-62°C (-80°F)	-70°F Max.
Flash Point, °C (°F)	ASTM D92	236°C (455°F)	257°C (495°F)	243°C (470°F)	410°F Min.
Acid No. mg of KOH/g	ASTM D974	0.03 mg of KOH/g		0.03 mg of KOH/g	--
Corrosion-Oxidation* 72 Hrs. @ 177°C (350°F)	FTM 5308				** 72 Hrs. @ 177°C (350°F)
(a) % Change in Vis. @ 38°C (100°F)		+24.0%	+27.0%	--	-5 to +15
(b) Change in Acid No.		+4.16	+3.05	--	1.5 Max.
(c) Appearance After Test		Small amt. of light colored Insolubles	IBID	--	No sludge or Insolubles
(d) Change in Wt. (mg/cm^2)					
(1) 410 Steel		0.00 mg/cm^2	0.01 mg/cm^2	--	0.2 Max.
(2) 52100 Steel		0.01 mg/cm^2	0.01 mg/cm^2	--	0.2 Max.
(3) Silver		0.01 mg/cm^2	0.02 mg/cm^2	--	0.2 Max.
(4) Copper		0.05 mg/cm^2	0.08 mg/cm^2	--	0.6 Max.
(5) Aluminum		0.03 mg/cm^2	0.01 mg/cm^2	--	--

TABLE II. PHYSICAL AND CHEMICAL PROPERTY TEST RESULTS FOR SAMPLES C, D AND E FLUIDS (Continued)

Test	Method	Sample C	Sample D	Sample E	MIL-L-81846 Requirement
Thin-Film Stability 6-1/2 Hrs. @ 177°C (350°F)	MIL-L-81846 Para. 3.7				6-1/2 Hrs. @ 177°C (350°F)
(a) Evaporation, %		79%	53%	76%	75% Max.
(b) Tackiness		Slight	Slight	Very slight	None
(c) Lacquer/Sludge		Slight amt of lacquer	IBID	Very slight amt of lacquer	None
(d) Flow		Slightly restricted	Slightly restricted	Free flowing	Free flowing
Evaporation, %, 22 Hrs. @ 177°C (350°F)	ASTM D972	26.33%	5.99%	12.22%	22.0% Max.

* 5 liters of air/hr. is passed through sample
** 3 liters of air/hr. is passed through sample

TABLE III. FOUR-BALL WEAR TEST RESULTS FOR SAMPLES A AND B

Test		Method	Results (mm) Sample A	Sample B	MIL-L-83176 Requirement
Four-Ball Wear (Scar-Dia.) 1 Hr. @ 75°C (167°F)-1200 RPM		ASTM D-2266			1 Hr. @ 75°C (167°F) 600 RPM
	Load (Kg)				
52100	40		0.62	0.52	0.65 Max.
52100	20		0.39	0.36	--
52100	10		0.22	0.22	0.30 Max.
1 Hr. @ 75°C (167°F)-600 RPM					
	Load (Kg)				
440°C	40		1.44	1.86	--
440°C	20		0.44	0.58	--

TABLE IV. FOUR-BALL WEAR TEST RESULTS FOR SAMPLES C, D AND E

Test	Method	Results (mm) Sample C	Sample D	Sample E	MIL-L-81846 Requirement
Four-Ball Wear (Scar-Dia.) 1 Hr. @ 75°C (167°F)-1200 RPM	ASTM D-2266				
	Load (Kg)				
52100	40	0.74	0.68	1.13	--
52100	20	0.46	0.41	1.01	--
52100	10	0.27	0.22	0.78	--
1 Hr. @ 75°C (167°F)-600 RPM					
	Load (Kg)				
440C	40	2.67	1.43	1.08	--
440C	20	0.48	0.46	0.72	--

TABLE V. R-4 BEARING LUBRICANT LIFE TEST RESULTS FOR SAMPLES A AND B

Test Conditions		Results (Hrs.) Sample A	Sample B
Speed - 12000 RPM			
Load - 2.2N (1/2-lbf) Radial		40.4	18.0
- 22-N (5 lbf) Axial		100.0	20.0
Temp - 149°C (300°F)		86.0	20.0
Bearing - MPB (SR4MCH7 (Phenolic Retainer)*		100,0	20.0
		74.8	9.6
	Avg.	80.2	17.5

Test Cycle: 20 Hrs. Running
4 Hrs. Shutdown

*Vacuum Impregnated by MPB

TABLE VI. R-4 BEARING TEST RESULTS FOR SAMPLES C AND E

Test Conditions		Results (Hrs.) Sample C	Sample E
Speed - 12000 RPM			
Load - 2.2N (1/2-lbf) Radial		140.0	9.6
22-N (5-lbf) Axial		57.5	12.0
Temp - 121°C (250°F)		150.5	16.2
Bearing - MPB SR4MCHH7 (Phenolic Retainer)*		60.0	6.5
		190.2	13.3
	Avg.	119.6	11.5

Test Cycle: 20 Hrs. Running

4 Hrs. Shutdown

* Vacuum Impregnated by MPB

APPENDIX A

PROPOSED MILITARY SPECIFICATION
LUBRICATING OIL, INSTRUMENT BEARING, SYNTHETIC HYDROCARBON

PROPOSED MILITARY SPECIFICATION
LUBRICATING OIL, INSTRUMENT BEARING, SYNTHETIC HYDROCARBON

1. SCOPE

1.1 This specification covers the requirements for three viscosity grades of synthetic hydrocarbon oils identified as Grades I, II and III.

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on date of invitation for bids, or request for proposal, form a part of this specification to the extent specified herein.

SPECIFICATIONS

Federal	
P-D-680	Dry Cleaning Solvent
QQ-S-624	Steel Bar, Alloy, Hot Rolled and Cold Finished (General Purpose)
QQ-S-766	Steel Plate, Sheet, and Strip-Corrosion Resisting
TT-T-656	Tricresyl Phosphate
Military	
MIL-S-13282	Silver and Silver Alloy

STANDARDS

Federal	
FED STD 791	Lubricants, Liquid Fuels, and Plated Products; Methods of Testing
Military	
MIL-STD-105	Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-290	Packaging, Packing, and Marking of Petroleum and Related Products

(Copies of specifications, and standards required by suppliers in connection with specific procurement functions should be obtained from the procuring activity, or as directed by the contracting officer).

2.2 Other Publications - The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on the date of invitation for bids or request for proposal shall apply.

American Society for Testing and Materials
ASTM Standards Parts 23 and 25

(Copies of ASTM publications may be obtained from the American Society for Testing and Materials, 1919 Race Street, Philadelphia, Pennsylvania 19103).

3. REQUIREMENTS

3.1 Qualification - The lubricating oil furnished under this specification shall be a product which has been qualified for listing on the applicable qualified products list at the time set for opening of bids (see 4.2.1). In addition, the retention of qualification for the lubricating oil on the applicable products list shall be dependent on periodic verification of continued compliance with the requirements of this specification (see 4.2.1.2).

3.1.1 Periodic qualification reevaluation - The lubricating oil shall pass a qualification reevaluation of samples taken from the first lot of lubricating oil, processed under the first contract or order after the product has passed the qualification inspection, and at intervals as considered necessary by the qualification laboratory or procuring activity to verify the consistency of production quality.

3.2 Materials - The materials used in compounding the lubricant shall consist of synthetic hydrocarbon fluids derived from α olefin oligimers. The fluids shall contain additives as specified.

3.2.1 Additives.

3.2.1.1 Oxidation Inhibitor. The oxidation inhibitor shall be a hindered bis-phenol. (An example of a known suitable additive is Ethyl 702 4,4' methylenebis (2,6-di-tertiary butyl phenol manufactured by the Ethyl Corporation). A minimum of 0.45 percent by weight shall be used.

3.2.1.2 Antiwear Agent. The antiwear agent shall be tricresyl phosphate conforming to TT-T-656. A minimum quantity of 0.9 percent by weight shall be used.

3.3 Physical Properties. The lubricating oil shall meet the physical properties appearing in Table I when tested as specified in Table IV.

TABLE I

Property	Requirement			Test Method
	Grade I	Grade II	Grade III	
Acid Number	1/	1/	1/	
Viscosity, mm^2/s				
100°C (212°F)	3.5 (min)	9.0 (min)	13.5 (min)	ASTM D445
40°C (104°F)	18.5 (max)	75.0 (max)	130.0 (max)	
-40°C (-40°F)	3500.0 (max)	30000.0 (max)	--	
Pour Point °C (°F)	-62(-80)max	-54(-65)max	-40(-40)max	D97
Flash Point, °C (°F)	227(440)min	249(480)min	260(500)min	D92
Evaporation, % 22 Hrs - 177°C (350°F)	28.0 (max)	7.5 (max)	6.0 (max)	D972

1/ Values needed for comparison purposes to determine compliance with requirements in paragraph 3.3.2.1

3.4 Corrosiveness and Oxidation Stability - When the lubricating oil is tested as specified in 4.4.1, it shall meet the following requirements:

3.4.1 Corrosion - The weight of the silver and steel strips shall not have changed by more than 0.2 milligrams per square centimeter of surface for each strip; the weight change for the aluminum shall be not more than 0.4 milligrams per square centimeter of surface, and the weight change for the copper shall be not more than 0.6 milligrams per square centimeter of surface.

3.3.2.1 Resistance to Oxidation - After the oxidation corrosion test (4.4.5) is completed, the viscosity of the oil at 40°C (104°F) and the acid number shall not have changed by more than the values shown in Table II.

TABLE II

Property	Requirement		
	Grade I	Grade II	Grade III
Corrosion-Oxidation % Change in Viscosity @ 40°C (104°F) (Max)	+30.0	+30.0	+5.0
Change in Acid No. (Max)	4.5	3.5	2.0

3.5 Lubricity - When tested in accordance with wear values for the lubricant shall exceed those specified in Table III.

TABLE III

Material	Speed (rpm)	Load (kg)	Avg Wear Scar Dia, (Max mm) Grade I	Grade II	Grade III
52100	1200	40	0.90	0.80	0.70
52100	1200	20	0.35	0.30	0.30
440C	600	20	0.60	0.60	0.60

3.6 Bearing Operating Life - When the lubricating oil is tested as specified in Table IV, the Grade I oil shall provide a minimum operating life of "TBD" hours at 250°F; the Grade II oil shall operate a minimum of "TBD" hours at 275°F and the Grade III oil shall operate for a minimum of "TBD" hours at 300°F.

3.7 Workmanship - The lubricating oil shall be a homogeneous, clear, bright liquid free from any visible impurities. Immediately before the oil is packaged, it shall be passed through a 0.5 micrometer membrane filter.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection - Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the supplier may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Compliance - Determination of compliance with provisions of the specification shall include the following:

(a) Qualification inspection

(a.1) Periodic qualification reevaluation

(b) Quality conformance inspection

4.2.1 Qualification Inspection - The qualification inspection performed by the qualification laboratory shall consist of a review for approval of the submitted manufacturer's report, and subjecting the qualification sample (4.3.1) to examination and testing for all the requirements of this specification.

4.2.1.1 Periodic Qualification Reevaluation - The periodic qualification reevaluation inspection performed by the qualification laboratory shall consist of examining and testing the periodic qualification reevaluation sample (4.3.2) for all the requirements of this specification. Delivery of the lubricating oil will not be delayed pending completion of periodic qualification reevaluation. If the results of the periodic qualification reevaluation inspection are in accordance with the requirements of this specification, the consistency of production quality will be thereby verified. Failure of the lubricating oil to pass a periodic qualification reevaluation inspection shall require that the acceptance and further shipment of lubricating oil to be withheld until the contractor has corrected the conditions which led to the failure (see 6.3.1). Further failure will constitute cause for rejection and removal from the Qualified Products List.

4.2.1.2 Retention of Qualification - The retention of qualification of products approved for listing in the Qualified Products List (QPL) shall be maintained by periodic verification to determine compliance of qualified lubricating oil with the requirements of this specification. Periodic verification may be made by certification unless otherwise specified by the activity responsible for the Qualified Products List and shall be at intervals of no more than 2 years.

4.2.2 Quality Conformance (Lot by Lot) Inspection - The quality conformance inspection shall include examining and testing the quality conformance samples (4.3.3.2) for conformance to all the Section 3 requirements and an examination of samples of filled containers (4.3.3.3) for conformance with Section 5 packaging, packing, and marking requirements.

4.3 Sampling and Acceptability Criteria

4.3.1 Qualification Samples - The qualification sample shall consist of two 1-quart containers of lubricating oil for which qualification is desired. The sample shall be accompanied by a report from the manufacturer or a commercial laboratory. The report shall show individual and average results for all requirements of this specification. The samples and reports shall be forwarded to the Aero Materials Division, Aircraft and Crew Systems Technology Directorate, Naval Air Development Center, Warminster, Pennsylvania 18974. The samples shall be plainly identified by securely attached durable tags or labels marked with the following information:

Sample for qualification inspection
LUBRICATING OIL, INSTRUMENT BEARING, SYNTHETIC HYDROCARBON
Military Specification
Name of Manufacturer
Product code name
Date of manufacture
Contract or order number
Batch number

4.3.2 Periodic Qualification Reevaluation - The periodic qualification reevaluation sample shall consist of two 1-quart containers of lubricating oil selected at random from first lot of lubricating oil processed under the first contract or order after the product has passed the qualification inspection. Additional qualification reevaluation samples may be taken at such intervals as considered necessary to verify the consistency of production quality. Periodic qualification reevaluation samples shall be forwarded to the laboratory responsible for qualification (see 4.3.1). The samples shall be plainly identified by securely attached durable tags or labels marked with the following information:

Sample for qualification reevaluation
LUBRICATING OIL, INSTRUMENT, BEARING, SYNTHETIC HYDROCARBON
Specification
Name of manufacturer
Product code number
Date of manufacture
Contract or order number
Batch number

4.3.3 Quality Conformance Samples - The quality conformance sample shall consist of a sample for tests (4.3.3.2) and a sample of filled containers (4.3.3.3). Samples shall be labeled completely with information identifying the purpose of the sample, name of product, purchase description number, date of manufacture, date of sampling, and contract number. Individual samples shall not be mixed, shall be placed in separate air-tight and water-tight containers, and shall be nearly filled, covered and sealed to prevent atmospheric effects.

4.3.3.1 Inspection Lot - A lot shall consist of material produced by one manufacturer under essentially the same manufacturing conditions. Each batch shall constitute a lot.

4.3.3.2 Sample for Tests - The sample for tests shall be one container of lubricating oil, taken at random from each lot of lubricating oil to be offered for delivery under a contract or order. A lot shall be unacceptable if a sample fails to meet any of the test requirements specified.

4.3.3.3 Sample for Examination of Filled Containers - A random sample of filled containers and a sample of shipping containers fully prepared for delivery shall be selected from each lot of lubricating oil in accordance with MIL-STD-105 at inspection level II and acceptable quality level (AQL) = 2.5 percent defective.

4.4 Test Methods - Tests shall be performed in accordance with Table IV and 4.4.1 to 4.4.5.

TABLE IV

TEST METHODS

Requirement	ASTM Method
Kinematic Viscosity	D445
Acid Number	D974 or D664
Pour Point	D97
Flash Point	D92
Evaporation 1/	D972
Evaluation in Bearings 2/	D3337

1/ Oven instead of oil bath may be used providing additional length of tubing is added in order to insure air temperature is within ± 2°C (4°F) of test temperature.

2/ Test bearing retainer shall be one-piece snap-type phenolic, vacuum impregnated with the test lubricant.

4.4.1 Corrosion and Oxidation Stability - The corrosion and oxidation stability shall be performed at 177°C (350°F) in accordance with Method 5308 of FED-STD-791 with the following modifications: The test shall be run for 72 hours. An electrolytic grade silver (conforming to MIL-S-13282, Grade A) test square shall be substituted for the cadmium plated steel square. The mild, carbon steel (QQ-S-698) test square shall be replaced with a square conforming to QQ-S-624, Composition FS E52100. The magnesium square shall be replaced with a Type 410 steel square conforming to QQ-S-766. The viscosity at 40°C (104°F) shall be performed within six hours of the completion of the oxidation test period.

5. PREPARATION FOR DELIVERY

5.1 Packaging - Unless otherwise specified, packaging shall be Level A.

5.1.1 Level A - The lubricating oil shall be packaged in 4 oz. wide-mouthed brown glass bottles. Screwcaps shall be polyethylene or

polypropylene with a liner of aluminum foil. The caps shall be compatible with synthetic hydrocarbon oil. The bottles shall be rinsed with filtered MIL-C-81302 and dried with clean filtered air.

5.2 Packing and Marking - Packing and marking shall be in accordance with MIL-STD-290.

6. NOTES

6.1 Intended Use - This oil is intended for use in precision instrument and miniature ball bearings, for the temperature range of -55°C (-67°F) to 150°C (302°F).

6.2 Ordering Data - Procurement documents should specify the following:

(a) Title and number of this specification

(b) Levels of details of packaging and packing

(c) Details of marking

(d) Quantity desired

6.3 Qualification - With respect to products requiring qualification, awards will be made only for such products as have prior to the time set for opening of bids, been tested and approved for inclusion in the applicable Qualified Products List whether or not such products have actually been so listed by that date. The attention of the suppliers is called to this requirement, and manufacturers are urged to arrange to have the products they propose to offer to the Federal Government, tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. The activity responsible for the Qualified Products List is the Naval Air Systems Command, Department of the Navy, Washington, DC 20361; however, information pertaining to qualification of products may be obtained from the Aero Materials Division, Aircraft and Technology Directorate, Naval Air Development Center, Warminster, Pennsylvania 18974.

6.3.1 The lubricating oil furnished under contract should be identical within commercial limits to the qualification samples which have been inspected and approved. In the event that the lubricating oil furnished under contract is found to deviate from the composition of the approved product, or if the product fails to meet all the requirements of this specification, or that the product fails to perform satisfactorily, approval of such products will be subject to immediate withdrawal from the Qualified Products List.

6.4 To obtain maximum benefit from filtration through filters (0.5 microns or smaller) and to maintain product cleanliness, the filling operation should take place under clean room conditions, or in a laminar flow clean bench.

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